

## **A Framed Panel and Related Method of Manufacture**

### **Field of the Invention**

This invention relates generally to framed panels and fenestration products and more particularly but not  
5 limited to products made from thermoplastic profiles welded around an insulating glass unit.

### **Background of the Invention**

To improve manufacturing efficiency and reduce product costs, various attempts have been made in recent  
10 years to develop integrated insulating glass / window frame production systems.

One example which is described in a presentation given at InterGlass Metal 97' was developed in Germany by Meeth Fenster. With this production system, the window is  
15 fabricated from plastic channel window frame profiles that are assembled around an insulating glass (IG) unit and corner welded using conventional hot plate technology. During the assembly process, the unit is held in position by means of a hot melt butyl adhesive bead that is located  
20 centrally in the frame channel. Twin silicone thermosetting glazing sealant beads are then applied in the two gaps either side of the IG unit. After assembly, the windows are stored in a truck container ready for shipping and the truck containers are left parked outside the factory for a few  
25 hours while the two-part silicone sealant is cured. For the Meeth production system, there are four main drawbacks. First, because of the butyl adhesive bead, the glazing channel cannot be drained and this creates potential IG durability problems. Second, conventional hot plate welding  
30 is a slow process that is complicated by the need for corner

flash removal. Third, the sash frame assemblies cannot be shipped until the two-part thermosetting sealant is fully cured. Fourth, the Meeth production is largely a manual process with manual loading of the individual frame profiles into the welding clamping fixtures and manual application of the sealant beads.

A second example of an integrated IG/window frame system is described in US Patent 5,622,017 issued to Lynn et al. and assigned to the Andersen Corporation. As with the Meeth system, the Andersen window is also fabricated from plastic channel frame profiles that are assembled around an IG unit and corner welded using conventional hot plate technology. In comparison with the Meeth System, the Andersen profile incorporates conventional plastic glazing fins on one side of the channel frame profile. A structural thermosetting sealant is then applied to one side of the unit and the single glazing sealant bead is allowed to cure. Because the IG glass unit is not held in position, the frame subassembly cannot be moved for several hours while waiting for the sealant to cure. In addition, the unit cannot be accurately centered within the channel profile and so the process of sealant application cannot be easily automated.

As described in US Patent 5,902,657 issued to Hanson et al., the channel frame profiles can be joined at the corners using friction welding with a moveable U-shaped metal platen that rapidly moves back and forth melting the plastic at the interface joint. As with conventional hot plate welding, the metal platen is then removed and the matching ends of the framing profiles are then pressured against each other. From a practical perspective, this solution is difficult to implement because as the metal plate is removed, the molten plastic material is also

removed resulting in a poor weld assembly. A further concern is that the IG unit is held in position by the sloped channel walls and as a result there are potential glass breakage problems at the corners.

5           A third example of an integrated IG/window frame system is described in PCT application CA02/000842 by Field et al (See Figures 21-23 therein). Again, the frame assembly is welded using friction welding but instead of using a metal platen, a plastic web is used that is vibrated  
10 back and forth using an inverted vibratory welding head. To avoid potential glass breakage problems, the IG unit is isolated from the plastic channel frame profiles using conventional rubber setting blocks. However, because the unit is not firmly held in position and is not accurately  
15 centered, the sealant application process cannot easily be automated. In addition, the profiles have to be manually loaded into the clamping fixtures and this slows down the production cycle time.

### **Summary of the Invention**

20           According to one aspect of the present invention, there is provided a framed panel unit comprising a panel; a plurality of thermoplastic frame members disposed along the edge of said panel; each frame member having first and second opposed side walls defining a channel therebetween,  
25 the edge of said panel being received within the channel of each frame member; the channel of each frame member having spacer means therein including a first spacer between said panel and said first side wall for spacing said panel from said first side wall and a second spacer between said panel  
30 and said second side wall for spacing said panel from said second side wall, and where prior to welding together the

ends of said frame profiles, the spacer means retain frame members on the panel.

One preferred arrangement is where at least one of said first and second spacers is positioned below the top of a respective channel wall to provide an open gap at the top of the channel between the panel and the side wall for receiving sealant. Advantageously, in this arrangement, spacers are provided in the channel, either side of the panel to center the panel in the channel and to also hold the panel in position during an assembly process, for example during application of a sealant, e.g. a reactive thermoplastic sealant, to both sides of the panel along a frame member.

In this arrangement, the spacers also resiliently retain the frame members on the panel when the frame members are unconnected so that the frame members can be positioned and held in place on the panel before the frame members are connected together, for example by welding. This also facilitates handling of the unit by allowing the various components to be moved and transferred together as whole between assembly stations in a production process and, in particular, facilitates the transfer and loading of the frame members into a welding apparatus so that this loading process may be automated, rather than manual.

One or both spacers may be formed separately from the frame member, or may be formed integrally therewith. One or both spacers may comprise a discrete protrusion extending into the channel for engaging a portion of the panel adjacent an edge thereof. Either one or each protrusion may have an upper surface which is deflected downwards to engage the surface of the panel so that when

the pressure applied to the panel by the protrusion is increased if the frame member is pulled in a direction away from the panel, making it difficult to withdraw the frame member from the panel when installed thereon.

5           When separately formed from the frame members, the first and second spacer may be joined together by a third intermediate spacer which spaces the edge of the panel from the base of the channel. The first, second and third spacers may thereby form a U-shaped insert and the first and  
10 second spacers may be hingedly coupled to the third spacer and may be integrally formed therewith. The spacer insert may include locator means for positioning the insert at a predetermined lateral position between the side walls of the channel, which is particularly advantageous when, due to  
15 manufacturing tolerances, the distance between the side walls of the channel are greater than required to accommodate the width of the insert. In one embodiment, the base of the channel has oppositely sloped upper surfaces which slope transversely of the channel and the locator  
20 means includes first and second oppositely sloped lower surfaces of the third spacer which engage the sloped surfaces of the channel to urge the third spacer towards a predetermined position within the channel on applying a force, for example the weight of the panel, to the third  
25 spacer towards the base of the channel.

In one embodiment, the frame members are welded together by friction welding, and preferably by means of a weldable junction piece disposed between adjacent ends of the frame members. The junction piece may be a flat planar  
30 flange or may also incorporate integral legs that help position the framing members in the assembly process. In one embodiment, the framed panel unit includes a reactive

thermoplastic sealant material along the junction between one or both outer surfaces of the panel and the frame member. The sealant material may have a high degree of stiffness (high modulus) to increase the structural strength and rigidity of the framed panel unit. The reactive thermoplastic sealant may for example be polyurethane or silicone based.

Advantageously, as the spacers effectively position and hold the panel in the desired position, relative thereto, the sealant need not have any open time to allow the panel to be repositioned relative to the joined frame members, and no repositioning is required. This allows a warm or hot applied thermoplastic sealant to be used which cools down almost immediately on its application to the panel unit so that once the application process is complete, the unit can be moved almost immediately to the next production stage, if any, for shipment, or for storage, resulting in a fast and more efficient production process. In one embodiment, the sealant may comprise a reactive thermoplastic sealant that may have an open time of 2 seconds or less but which after exposure to moisture chemically cures and bonds to the glass.

According to another aspect of the present invention, there is provided a panel unit comprising first and second opposed sheet members; a spacer between said sheet members spacing said sheet members apart, said spacer comprising a thermoplastic sealant material and being located proximate an edge of the sheet members; a frame member having a channel formed therein, said edge being disposed within said channel; and a reactive thermoplastic sealant material bonding said sheets to said frame member.

Advantageously, the provision of a reactive thermoplastic sealant material which structurally bonds the sheets to the frame member allows the perimeter seal and spacer between the sheet members to be simplified and the material used to be considerably reduced. In one embodiment, the perimeter edge seal between the glazing sheets only consists of a thermoplastic sealant spacer.

According to another aspect of the present invention, there is provided a method of forming a framed panel, comprising the steps of: (a) providing a panel to be framed; (b) providing a plurality of frame members for framing said panel, each frame member having a channel formed therein for receiving an edge portion of said panel and resilient means within said channel for spacing the panel from opposed side walls of said channel and for resiliently retaining said panel in said channel; (c) inserting said panel into the channel of each frame member such that said frame members are held on said panel by said resilient means; and (d) joining the ends of adjacent frame members together by welding. In one embodiment, the framing members are interconnected by junction pieces prior to transferring the frame/panel subassembly to the welding apparatus.

According to another aspect of the present invention, there is provided a frame member for a panel, comprising first and second opposed side walls defining a channel therebetween for receiving said panel; first and second pre-formed spacers comprising a resilient material inserted in said channel; the first spacer being positioned against said first side wall for spacing one side of said panel therefrom and said second spacer being positioned

against said second side wall to space the other side of said panel therefrom.

According to another aspect of the present invention, there is provided a spacer component for use in mounting a panel within a channel of a frame member, comprising a base portion for spacing said panel from the base of said channel; a side portion extending from said base portion for spacing said panel from a side wall of said channel; and a protrusion extending from said side portion for engaging a face of said panel and for resiliently retaining said panel in said frame member.

According to another aspect of the present invention, there is provided a frame member comprising first and second opposed sidewalls defining a channel therebetween and protrusions extending from each sidewall into said channel for resiliently retaining a panel therebetween. In one embodiment, the protrusions that extend from each side wall are flexible fins and according to another embodiment, a bulb seal also extends from each side wall and is located at the top of each framing channel member.

According to another aspect of the present invention, there is provided a frame member comprising first and second opposed sidewalls defining a channel therebetween, at least one sidewall having an elongate recess formed therein extending along the channel and positioned below the top of a respective sidewall.

#### **Brief Description of the Drawings**

Figure 1 shows an exploded elevation view of U-channel sash frame profiles assembled around an insulating glass panel.

Figure 2 is a vertical cross section perspective corner detail of a U-channel sash frame incorporating a double glazed insulating panel.

Figure 3 is a perspective view of a single corner vibration welding apparatus.

Figure 4A is a plan view of a single corner, vibration welding apparatus with the extrusions installed in the fixtures prior to the welding process.

Figure 4B is a view similar to Figure 4A showing the single corner vibration welding apparatus during the welding process.

Figure 5 shows a cross section sash frame detail of a U-channel sash frame profile incorporating a conventional dual-seal insulating glass panel and where the framing profiles are temporarily held in position by means of folding rubber spacer inserts.

Figure 6A is a perspective view of the folding rubber spacer inserts prior to insertion within the U-channel sash frame profile.

Figure 6B is a perspective detail view of the folding rubber spacer inserts after insertion within the U-channel sash frame profile.

Figure 7A shows a cross section detail of the folding rubber spacer and the perimeter edge of an insulating glass panel just prior to the insertion of the panel into the folding rubber spacer.

Figure 7B is cross section detail of the perimeter edge of an insulating glass panel after the panel has been inserted into the folding rubber spacer.

Figure 8A shows an exploded cross section detail of three window sash frame components, including: (i) bottom perimeter edge of insulating glass panel, (ii) an unfolded rubber spacer insert and (iii) U-channel sash frame profile.

Figure 8B shows a cross section detail of the folding rubber spacer inserted within the U-channel sash frame profile.

Figure 8C shows the insulating glass panel inserted within the U-channel sash frame profile.

Figure 9 shows a cross section detail of the perimeter edge of a single-seal insulating glass panel incorporated within a U-channel sash frame profile.

Figures 10A-10D show schematic plan views of the production process of an integrated IG/window frame assembly.

Figure 10A shows a schematic plan view of the insulating glass panel.

Figure 10B shows a schematic plan view of the insulating glass panel with U-shaped plastic framing profiles loosely assembled around the insulating unit.

Figure 10C shows a plan view of the insulating panel/plastic sash frame subassembly with junction pieces inserted at the corners.

Figure 10D shows a plan view of the completed window sash subassembly.

Figure 11A is a cross section plan view detail of a frame corner assembly where the thermoplastic plastic profiles are vibration welded at the corner using a corner junction piece with a diagonal web and integral legs.

5           Figure 11B is a cross section detail of the frame corner assembly as shown in Figure 11A where the plastic framing profile is ultrasonically spot welded to the integral legs of the corner junction piece.

10           Figure 11C shows a vertical cross-section detail through the hollow profile shown in Figure 11A.

Figures 12A-12E show schematic plan views of a high volume production process of an integrated IG/frame assembly.

15           Figure 12A shows a plan view of the frame profiles assembled around an insulating glass panel.

Figure 12B shows a plan view of the insulating glass panel/frame subassembly.

Figure 12C shows a plan view of the insulating glass panel/frame subassembly suspended below a gantry.

20           Figure 12D shows a plan view of a four headed horizontal friction corner welder with the insulating glass panel/frame assembly dropped into position.

25           Figure 12E shows a plan view of the four headed horizontal friction corner welder with the insulating glass panel/ frame assembly clamped into position just prior to the welding process.

Figure 13 is a vertical cross section of a U-channel sash frame window incorporating a double glazed

insulating panel and thermoplastic U-channel framing profiles with integrally formed flexible fin spacers and glazing bulb seals.

#### Detailed Description of the Preferred Embodiments

5           Referring to the drawings, **Figure 1** shows an exploded elevation view of a sash window **20** where the U-shaped thermoplastic framing profiles **21** are assembled around an insulating glass panel unit **25**. Typically, the insulating glass panel unit **25** consists of two glass  
10 sheets **26,27**, which are shown more clearly in Figure 5, and are separated by a perimeter edge seal. As described in more detail in **Figures 3 to 5**, the end joint surfaces **23,24** of the sash frame profile members **21** are friction welded at the corners using thermoplastic planar flange junction  
15 pieces **22**. Folding rubber spacer inserts **30** are used to hold the insulating glass panel **25** in position within the U-shaped channel profile **21**. Prior to the welding process, the folding rubber spacer inserts **30** also retain the framing profiles **21** in position on the insulating glass panel **25**.  
20 In addition, the folding rubber spacer inserts **30** also prevent the vibrating junction piece **22** from striking the corners **31** of the insulating glass panel **25** during the welding process. The folding rubber spacer inserts **30** can be made from various resilient materials with one preferred  
25 material being EPDM rubber.

**Figure 2** shows an exploded perspective corner detail of a U-channel sash frame window **20** incorporating a double glazed insulating panel unit **25**. The ends **23,24** of the plastic framing profiles **21** are miter cut and vibration  
30 welded to a plastic planar flange junction piece **22**. The framing profiles **21** can be made from various thermoplastic

materials but generally, the preferred material is polyvinyl chloride (PVC). In order for the junction pieces 22 to strongly bond to the framing profiles 21, the junction pieces 22 are made from essentially the same type of plastic material as the framing profiles 21.

Figure 3 shows a top perspective view of a prototype single corner vibration welding apparatus 32. The apparatus consists of five main components:

1. Vibratory Head

A linear vibratory head 33 that incorporates a top plate 34 which vibrates back and forth very rapidly in a predetermined plane.

2. Junction Piece Holding Fixture

A junction piece holding fixture 35 which is directly attached to the top plate 34 and firmly holds the planar flange junction piece 22 in position.

3. Moveable Framing Fixtures

Two moveable framing fixtures 36 and 37 incorporate clamping devices 38 that firmly hold the framing profiles 21 in position.

4. Control Systems

A control system 39 that regulates the various operating parameters of the vibration welding apparatus 32 including: weld time, hold time, joint pressure, weld depth, amplitude, frequency and voltage.

## 5. Machine Frame

A machine frame 40 which provides the structure that supports the other components.

Figure 4A shows a plan view of a single corner, vibration welding apparatus 32 in an open position. The linear vibration welding apparatus 32 features a vibratory head 33 that linearly moves back and forth in a pre-determined plane. The vibratory head 33 is similar to the vibratory heads used on commercially available linear vibration welders such as the Branson Mini Welder, but unlike these commercially available products, the vibratory head is turned upside down as this allows for more flexible and easy positioning of the framing profile members 41 and 42 during the frame assembly process. A flat plate 43 is bolted to the top surface of the vibratory head 33. As with standard vibration welders, the vibratory head 33 is bolted to a separate heavy cast iron support (not shown) and isolated from the cast iron support structure (not shown) using rubber mounts. This cast iron support structure is in turn bolted to a machine frame 40 that positions the vibratory head 33 at a convenient working height.

Flat plate metal sheets 44 are bolted to the top surface of the machine frame 40 but this top working surface is separated apart from the vibratory head 33 so that a minimum of vibratory movement is transferred to the machine frame 40. Moveable profile fixtures 36 and 37 are supported on guide rails 45 directly attached to the top table plate 44 and these fixtures hold the framing profiles 41 and 42 in position. The moveable profile fixtures 36 and 37 move over the vibratory head 33 but there is no direct contact except where the framing profiles 41 and 42 contact the junction

piece 22. The moveable fixtures also allow for the miter cut ends 23, 24 of the framing profiles 41 and 42 to be positioned parallel to the planar flange 48 of the junction piece 22.

5           A fixed holding fixture 35 for the junction piece 22 is located so that the planar flange 48 of the junction piece 22 is in a balanced central position. The holding fixture 35 which is directly attached to the top plate 43 of the vibratory head 33, firmly holds the removable tab 49 of  
10 the junction piece 22 in position.

**Figure 4B** shows a plan view of the vibration welding equipment 32 in operation with the miter cut ends 23 and 24 of the framing profiles 41 and 42 being pressured against the planar flange 48 of the junction piece 22. By  
15 vibrating the junction piece 22 back and forth and by simultaneously pressuring the framing profiles 41 and 42 against the planar flange 48 of the junction piece 22, friction heat is generated at the two joint interfaces 50 and 51. When a molten state is reached at the two joint  
20 interfaces 50 and 51, the vibration is stopped and the perpendicular pressure is then maintained briefly while the molten plastic solidifies to form two welded joints 52 and 53 on either side of the planar flange 48. In order to provide for even weld strength, essentially the same  
25 perpendicular engagement force has to be simultaneously applied to each side of the junction piece 22.

          One of the key advantages of vibration corner welding is that by incorporating flash traps or weld beads within the junction piece 22, it is feasible to eliminate  
30 the need for mechanical flash removal and as a result, there are substantial equipment cost savings.

Although frame assemblies can be manufactured using a single corner welder, it is more productive if two or more corners are welded simultaneously. The operation of a vertical four head welder is described in PCT Application  
5 CA02/00842 by Field et al. As with conventional hot plate welders, the profiles are separately loaded into the holding fixtures and the miter cut corners are welded in either a one stage or two stage operation.

With a two stage process, two diagonally opposite  
10 corners and are first welded together. For each corner weld, the process is essentially the same as with a single corner vibration welder. Both sets of framing profiles are independently pressurized against the two diagonally opposite junction pieces. The next step is for the other  
15 set of diagonally opposite corners to be welded together and the assembled frame is then unloaded.

Because the friction welding process is so fast (3 to 6 seconds), this two stage process does not significantly increase cycle time and compared with  
20 simultaneously welding all four corners, the key advantage is that the required movement and control of the heads is greatly simplified.

For a conventional four head, hot plate welder, the overall cycle time is about 2 minutes and this overall  
25 cycle time includes: profile loading, corner welding, cool down and frame unloading. In comparison, the overall cycle time for the two-stage vibration welding process is less than 30 seconds and so this represents a significant increase in productivity.

30 Instead of a two stage process, a second option is to simultaneously weld all four corners in one operation.

During the vibration welding process, each head has to move fractionally and because the head movements involved are so small and so complex, the control system for this simultaneous four headed welding operation is very complex  
5 and requires very sophisticated software.

A further major advantage of vibration corner welding is that it is feasible to weld around an insulating glass unit. With a four headed welder, the frame profiles are loaded into the framing fixtures and the insulating  
10 glass unit is positioned between the four welding heads. The four heads then move centrally into position so that the U-shaped framing profiles overlap the perimeter edge of the insulating glass unit. With the insulating glass unit in position, the miter cut frame profiles are then welded using  
15 friction corner welding.

**Figure 5** shows a bottom cross section detail of a U-channel sash window 20. The U-shaped channel sash framing profiles 21 are assembled around a dual seal insulating glass panel unit 25. The two gaps 57 and 58 between the  
20 insulating glass panel unit 25 and the framing profile 21 are filled with glazing sealant material 59 forming glazing beads 54 and 55. Various glazing sealant materials can be used but one preferred material is a reactive thermoplastic sealant.

25 Compared to conventional two-part thermosetting sealants, the advantage of a reactive thermoplastic sealant is that the one part sealant is warm or hot applied so that after a few seconds cool down, the material develops high green strength allowing the window units to be almost  
30 immediately handled. Compared to conventional widow glazing seal application where there is a need for some open time

during the application process, the open time for the reactive thermoplastic sealant materials can be less than two seconds. In addition through a moisture cure process, the reactive thermoplastic material is chemically cured  
5 creating a strong adhesive bond between the glass sheets and the framing profiles.

Various types of reactive thermoplastic sealants can be used but one preferred material is a reactive hot melt polyurethane adhesive that is manufactured by National  
10 Starch and Chemical Company under the trade name of Purfect Glaze. A second preferred material is a reactive hot melt silicone that is manufactured by Dow Corning under the trade name of Instant Glaze. Compared to the reactive silicone material, the reactive polyurethane material generally  
15 provides for higher adhesion strength.

The modulus or stiffness of the Purfect Glaze sealant can be varied and generally, a high modulus material is preferred as this allows for the glass sheets to be firmly bonded to the framing profiles. As a result,  
20 structural advantage can be taken of the stiffness of the glass sheets 26,27 so that the structural performance of the framing profiles 21 is enhanced allowing for a reduction in profile size as well as the possible elimination of metal reinforcement that is typically required for large size PVC  
25 windows.

With a high modulus, stiff sealant material and because of the high differential expansion between the plastic PVC framing profiles 21 and the glass sheets, 26,27 there is potential for cold temperature glass breakage.  
30 However, our experience has shown that even at quite extreme Canadian winter temperatures (ie below -30°C) glass breakage

is not a problem. This is because the plastic PVC material is sufficiently ductile that differential expansion within the plastic profile cross section can be accommodated. As well, the plastic framing profiles 21 are firmly adhered to the perimeter side faces of the glass sheets 26,27 as opposed to the bottom edge where glass breakage problems are accentuated due to glass edge micro cracks created during the glass cutting process.

At cold outside temperatures, a further concern is that there can be IG edge seal failure due to loss of adhesion between the glass sheets 26, 27 and an IG edge spacer. To eliminate this problem, there is a need for the perimeter edge seal to be somewhat flexible and for a conventional dual-seal design. One preferred option is use an inner desiccant-filled PIB/butyl spacer 62 that is backed by outer structural thermosetting sealant 63. Other IG dual-seal options include: flexible desiccant-filled silicone or EPDM rubber foam spacer (Trade name: Super Spacer) backed by hot melt butyl sealant.

Folding rubber spacer inserts 30 are used to accurately center the insulating glass panel unit 25 within the frame profile 21. These inserts 30 temporarily hold the framing members 21 on the panel unit 25 and also positions the panel 25 in the sash frame subassembly while it is transferred to the sealant gunning application station.

The bottom sides 64 and 65 of the U-channel frame profile are chamfered and this helps position the folding rubber spacer inserts 30 within the sash frame profile 21. To further help hold the folding rubber spacer inserts 30 in position, the sidewalls of the profile also incorporate inner ledges 66 and 67. The bottom section of the folding

rubber spacer inserts 30 also incorporate a V-shaped opening that provides for water drainage from the glazing cavity 69.

To provide for consistent application, the sealant beads 54 and 55, are produced using robotic application equipment. One option is separately apply each bead using a standard robot and where the sash assembly frame is rotated through 180° degrees after the application of the first bead 54. A second option is to apply both beads 54 and 55, simultaneously using automated double-head sealant application equipment that operates in a similar manner to automated sealant gunning equipment used for insulating glass sealing. For double bead application, the sash frame assembly is typically in a vertical position and to ensure that the sealant material does not deform or drip particularly on the top edge, the thermoplastic sealant material needs to have a high viscosity.

Figure 6A shows a perspective view of the folding rubber spacer insert 30 prior to installation within the U-channel profile 21. The side wall sections 72 and 73 space the IG unit 25 away from the channel walls of the framing profile. The folding rubber spacer insert 30 incorporates V-notches 70 and 71, that allow the rubber spacer insert to be folded at the corners. The purpose of the V-notches 70 and 71, is to allow the inserts 30 to be easily installed within the frame profile 21 prior to the insertion of the IG panel 25. The V-notches 70 and 71 also help the folding rubber spacer insert 30 accommodate dimensional tolerances in the frame profile. The rubber inserts 30 can be made from a variety of different rubber materials with one preferred option being EPDM rubber.

Although a one piece assembly is shown in **Figure 6A**, it can be appreciated by those skilled-in-the-art that the side wall sections could consist of two separate spacers that are individually attached to the side walls of the channel profile. Similarly the bottom section of the folding rubber spacer insert could also consist of a separate spacer that is positioned in the bottom channel of the framing profile.

**Figure 6B** shows a perspective view of the folding rubber spacer insert **30** with side sections **72** and **73** folded at right angles to the bottom section **74**.

**Figure 7A** shows an exploded cross section detail of the folding rubber spacer insert **30** and the perimeter edge **75** of an insulating glass unit panel **25** just prior to the insertion of the panel unit **25** into the folding spacer insert **30**.

**Figure 7B** is a cross section detail of the perimeter edge **75** of an insulating glass panel **25** after the panel has been inserted into the folding rubber spacer insert **30** that is held within a U-channel frame profile (not shown). The side wall sections **72** and **73** of the folding rubber spacer insert **30** incorporate a protrusion or positioning flange **76** that extends beyond the inner wall surfaces **77** of the side walls **72** and **73**. As the panel unit **25** is inserted into the folding rubber spacer **30**, the protrusion **76** is compressed downwards and so as a result, the insulating glass panel **25** is firmly wedged in position and centered within the frame profile **21**.

**Figure 8** shows the production steps involved in the fabrication of the integrated IG/ sash frame assembly.

**Figure 8A** shows an exploded bottom cross section detail of a window sash frame. There are only three components shown: an insulating glass panel **25**, a folding rubber spacer insert **30** and a U-channel sash frame profile **21**. The bottom faces **78** of the rubber spacer insert **30** are coated with a low-friction coating **79** (see dotted line). The low friction coating **79** allows the rubber spacer insert **30** to slide along the U-channel framing profile **21** during the friction corner welding process. The low friction coating **79** is compatible with standard IG sealant materials and one preferred material option is a polyurethane-based coating. In comparison, the top faces **109** of the rubber insert **30** preferably have a high friction coefficient and do not move in position during the friction corner welding process.

**Figure 8B** shows an exploded bottom cross section detail of a window sash frame with the folding rubber spacer insert **30** inserted within the sash frame profile **21**. The rubber spacer inserts **30** can be inserted manually or alternately, the spacer inserts **30** can be automatically inserted as part of the profile cutting and fabrication process.

**Figure 8C** shows a bottom cross section detail of a window sash frame **20** with the IG panel unit **25** installed within rubber spacer insert **30** that is held in position within the sash frame profile **21**. The rubber spacer inserts **30** center the IG panel unit **25** in the sash frame **21** and the corners of the frame assembly are then welded using friction corner welding techniques that are described in PCT Application CA02/000842. As well as centering the panel unit **25**, the rubber spacer inserts **30** also help isolate the IG unit **25** from any resonance or vibratory movement during

the welding process. The sash frame assembly is then transported to the automated frame sealing robot (not shown) with the rubber spacer inserts 30 holding the IG unit 25 in position.

5           It should be noted that although the friction corner welding process is carried out with the IG panel unit 25 in either a horizontal or vertical position, the sealant gunning operation is typically carried out with the panel unit 25 in a vertical position. By positioning the IG panel  
10 unit 25 in a vertical position, this ensures that the IG panel unit 25 is centered within the frame profile 21 and that there is no compression of the bottom rubber side wall sections 72 and 73. After the double bead application of the reactive hot melt sealant, the sash frame assembly can  
15 be immediately transferred to the next step in the production process which is typically hardware application. As a result through these various improvements in assembly methods, there is a continuous sash frame production process with increased throughput and productivity and no major  
20 production bottlenecks or delays.

Although a double glazed panel unit is illustrated in **Figure 8**, it can be appreciated by those skilled-in-the-art that a triple glazed unit could also be used. Alternatively using a different frame profile, the same  
25 production method can be used for welding around a single glass sheet and one option is for this single glass sheet would be as the center light of a triple glazed panel unit.

**Figure 9** shows a cross section bottom detail of a single seal IG panel unit 80 incorporated within a slim-line  
30 U-channel sash frame profile 81. In contrast to a dual seal IG unit, the perimeter edge seal assembly 82 consists of a

single barrier seal. Various single seal assemblies can be used including: the Intercept™ edge seal product marketed by PPG Inc. and the Swiggle Seal™ product marketed by TruSeal Inc.

5           One preferred single seal design is to use a thermoplastic spacer 83 that is made from desiccant filled butyl and/or polyisobutylene sealant material. The thermoplastic spacer 83 is marketed under the trade name of TPS and is directly applied to the glass using automated  
10 sealant gunning equipment manufactured by Bystronic Inc. A key advantage of the TPS spacer is that the material remains somewhat flexible and as a result, the spacer/edge seal assembly can accommodate some degree of glass movement and bowing even at cold temperatures. Typically, the TPS spacer  
15 is backed up by a structural thermosetting sealant such as polysulphide or polyurethane sealant (See **Figure 5**). However with integrated IG/sash frame assembly, the glass sheets 26 and 27, are structurally bonded to the frame profile 81 by means of structural sealant glazing beads 54,  
20 55 and so as a result, there is no need for an outer structural IG sealant to hold the glass sheets 26 and 27 in position. By eliminating this outer structural sealant, there are material and equipment cost savings and as well, the frame profile size can also be reduced resulting in  
25 additional material cost savings. A further production benefit is that there are no delays while waiting for the thermosetting sealant to cure and this provides for continuous sash frame production with the resulting productivity improvements and cost savings.

30           **Figure 10** shows the key production steps for assembling U-channel sash frame profiles 21 around an insulating glass panel unit 25. **Figure 10A** shows a

schematic plan view of an insulating glass panel unit 25.

**Figure 10B** shows a schematic plan view of the insulating glass panel unit 25 with U-shaped plastic framing profiles 21 loosely assembled around the insulating glass panel unit

5 **25.** **Figure 10C** shows a schematic plan view of the insulating glass unit/frame profile sub assembly 87 with corner junction pieces 22 inserted between the cut ends 23 and 24 of the framing profiles 21. The four corners of the sash frame subassembly 87 are then welded, using methods and  
10 techniques disclosed in PCT CA 02/000842 for example.

**Figure 10D** shows a schematic plan view of the completed sash frame window 20. As previously explained, the insulating glass panel unit 25 is held in position and centered in the U-shaped frame profile 21 using folding rubber spacer

15 inserts (not shown).

Although the production process is shown in schematic form in **Figure 10**, it can be appreciated by those skilled-in-the-art that the process can be fully automated using four headed production equipment as described in PCT  
20 Application CA02/000842. With a conventional, four headed hot plate welder, the overall cycle time is approximately 120 seconds and the time taken to manually load the four plastic profiles into the clamping fixtures is approximately 15 seconds. With four headed friction corner welder, the  
25 overall cycle time is less than 30 seconds but the task of manually loading the profiles takes 15 seconds while the actual weld time is less than 2 seconds.

Instead of preloading the profiles into the clamping fixtures of the four headed welder, one option with  
30 friction corner welding is to loosely fit the profiles around the insulating glass unit (See **Figure 10B**). The profiles 21 can be temporarily held in place, by the folding

rubber spacer inserts 30 (not shown) allowing the sub assembly of IG unit/frame profiles 87 to be transferred to the four-headed welder. The planar flange junction pieces 22 are then inserted and the corners welded using friction corner welding techniques. (See **Figure 10C**). As a result of pre-assembling the frame profiles 21 around the IG panel unit 25, the overall cycle time can potentially be reduced to less than fifteen seconds.

Finally, it should be noted that in **Figure 10** although schematic plan views are shown with the insulating glass panel unit 25 in a horizontal position, the various manufacturing operations can also be carried out with the insulating glass panel unit 25 in a vertical position.

Where a thermoplastic sealant spacer is used, the sealant is preferably applied directly onto the perimeter glass edge with the glass sheet in a vertical position. As previously noted, the double bead sealant gunning operation is also carried out with the IG/frame sub assembly in a vertical position and so if all the various assembly operations are consistently carried out with the glass sub assemblies in a vertical position, there are potential productivity improvements and cost savings.

**Figures 11A and 11B** show a cut out cross section plan view of a corner frame assembly 89 fabricated from square profile glass fiber filled PVC profile extrusions 90 and 91 and where the profiles 90 and 91 are vibration corner welded at using a junction piece 92 incorporating integral legs 93.

As shown in **Figure 11A**, the integral legs 93 of the junction piece 92 incorporate an integral spring centering device 94 that simplifies frame assembly. The

planar flange 48 of the junction piece 92 is first vibration welded to the miter cut ends 23 and 24 of the profiles 90 and 91. Because of the need to accommodate the vibration movement back and forth, the legs 93 only loosely fit within the profile.

As shown in **Figure 11B**, in order to provide for additional support, the plastic framing profiles 90 and 91 are ultrasonically spot welded to the legs 93 of the junction piece 92. A double tip welding head is typically used creating spot welds 95 and 96. Because the legs 93 only loosely fit within the profile, the ultrasonic welding process allows the plastic to flow in the gap between the junction piece legs 93 and the profile extrusions 90 and 91 creating an extra strong welded spot bond and reduced material flow on the exterior surface. Because of their complex shape, the junction pieces 92 are typically injection molded and have to be manufactured from essentially the same base thermoplastic resin material as the extruded profiles 90 and 91.

**Figure 11C** shows a vertical cross section through the hollow framing profile 91. The integral legs 93 of the junction piece 92 consist of a rigid flat bar 97 with a central positioning fin 98. The profile extrusion incorporates a half circular indentation 99 and this allows the positioning fin 98 to be centrally located.

**Figure 12** shows an alternative high volume production process for welding around an insulating glazing panel unit 25. **Figure 12A** shows a plan view of an insulating glazing panel unit 25 with U-Channel framing profiles 21 manually assembled around an insulating glazing panel unit 25 and where the profiles 21 are loosely

interconnected by junction pieces 92 that incorporate integral legs 93. **Figure 12B** shows a plan view of the insulating glass/frame subassembly 100 where the profiles 21 are positioned around the insulating glass panel unit 25 and where the profiles are in part held in position by folding rubber spacer inserts (not shown). **Figure 12C** shows a plan view of the insulating glass/frame subassembly 100 suspended below a gantry 101 and held in position by means of an adjustable clamping mechanisms 102. **Figure 12D** shows a plan view of four headed horizontal friction corner welder 103 where the insulating glass/frame subassembly 100 is transferred by the gantry 101 and dropped into position in the friction corner welder 103. The removeable tabs 49 of the junction pieces 92 are located in the junction piece holding fixture 35 that are attached to the vibratory heads 33. **Figure 12E** shows a plan view of the insulating glass/frame subassembly 100 where the frame profiles 21 are clamped in position in moveable framing fixtures 104 and where the subassembly 100 is squared prior to friction corner welding the four corners 29. After the welding process, the removable tabs 49 are automatically cut-off and the framing fixture clamps 104 are released. The assembled sash frame window 20 is then moved by the gantry 101 to the next window production operation.

Because with this high volume production process, the framing profiles are not manually placed in the profile fixtures, weld cycle time is substantially reduced to less than fifteen seconds per window unit and this results in a production output of two thousand windows per eight hour shift. It should be noted that although a high volume sash frame production method is described in **Figure 12**, it can be appreciated by those skilled-in-the-art that the same

production methods and apparatus can also be used to manufacture separate window frame assemblies.

**Figure 13** shows a bottom cross-section detail of a U-channel sash window profile **21** featuring flexible fin spacers **105** and glazing bulb seal **106**. U-shaped channel profiles **21** are assembled around the insulating glass panel unit **25**. The panel unit **25** is then inserted into the channel frame profile **21**. The double set of flexible fin spacers **105** that are integrally formed with the framing profile **21** are compressed downwards and hold the insulating glass unit **25** in position. Typically, the flexible fins **105** are made from flexible PVC plastic material and are extruded simultaneously with the PVC framing profiles.

The dual seal insulating glass panel unit **25** is supported on a rubber support pad **107** that is positioned centrally in the U-shaped framing profile **21**. The support pad **107** incorporates an opening **108** to allow for water drainage from the glazing cavity **69**. The flexible glazing bulb seal **106** that is also integrally formed with the framing profile **21** prevents rain water run-off from entering the glazing cavity **39**. The use of integrally formed flexible fin spacers and bulb seals does not provide for the same structural performance as the twin sealant bead assembly previously described in **Figure 5**. However for smaller residential windows the use of integrally formed spacers provides for adequate structural performance and with the added advantage of lower equipment, material and labor costs.